Fish 53



# WHITE BASS SAMPLING PROGRAM

## FINAL REPORT

Submitted to:

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# EXECUTIVE SUMMARY

White bass (Morone chrysops) were introduced into California at Nacimiento Reservoir, San Luis Obispo County, by the California Department of Fish and Game (DFG) in 1964. Illegal transport of white bass into Kaweah Reservoir and subsequent flooding in 1982-83 introduced white bass into the Tulare Basin. White bass distribution in California is a major concern of the DFG because white bass could severely impact important species such as chinook salmon (Oncorhynchus tshawytscha) in the Sacramento-San Joaquin River system.

The DFG contracted with Jones & Stokes Associates to determine the status of white bass in the San Joaquin River system. Fish were sampled in 280 river miles, including the San Joaquin River from Mossdale to Millerton Lake and the entire Kings River system. Sampling was conducted by three 2-person crews from July 14 to October 11, 1986. Fish were collected using gill nets, seines, fyke traps, boat electrofishing, and underwater observations.

A total of 21,062 fish representing 33 species was collected during the study. White bass were not collected or observed. Recommendations for future sampling programs are presented in this report.

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## Chapter 1

## INTRODUCTION

White bass (*Morone chrysops*) historically inhabited the Great Lakes region and Mississippi River drainages. An excellent game fish, white bass have been introduced into large warmwater reservoirs throughout the United States where fishing success for other species has declined (Jenkins and Elkin 1957). In 1964, the California Department of Fish and Game (DFG) considered the introduction of white bass into several warmwater reservoirs where angling was poor. A major criteria of reservoir selection was that the selected reservoir could not be a part of the Sacramento-San Joaquin River system; white bass are piscivorous and could pose a major threat to juvenile chinook salmon (*Oncorhynchus tshawytscha*) and other economically important species in this river system. Nacimiento Reservoir in San Luis Obispo County was chosen to receive small plants of white bass from 1965-68 because it has no connecting waterways to the Sacramento-San Joaquin River system, maintained a relatively poor fishery, and contained a large population of an underutilized prey species, threadfin shad (*Dorosoma petenense*). The introduction has been successful as Nacimiento Reservoir currently supports a highly productive white bass fishery (Chappell pers. comm.).

White bass were discovered unexpectedly in 1977 during routine sampling by the DFG in Kaweah Reservoir, Tulare County. Fish were transported illegally, probably by uninformed fishermen. Eradication efforts were underway in Kaweah Reservoir when heavy winter rains in 1982-83 caused water to spill over the Kaweah Dam spillway. White bass were carried in the flood flows to the Kaweah River below, and ultimately into Tulare Lake, the terminus of the Kaweah River. White bass were found several years ago in the Tule River below Success Dam, and in 1984 white bass spawning was observed in Tulare Lake by DFG biologists. In 1986, several gravid female white bass were sampled in Pine Flat Reservoir (Tribbey pers. comm.).

The spread of white bass into the San Joaquin drainage is of major concern to the DFG. White bass could now potentially move into the Sacramento-San Joaquin River system via several routes:

- by swimming up the South Fork Kings River to the North Fork or mainstem Kings River during high water years (Fresno Slough connects the North Fork Kings to the San Joaquin River)

- o by entering the Kings River via Pine Flat Reservoir flow releases or spill

- o by entering the San Joaquin River via several irrigation canals connected with the Kings River system.

As part of the continuing effort to monitor and control white bass movement in the Central Valley, DFG contracted with Jones & Stokes Associates to conduct fish sampling to determine the status of white bass in the San Joaquin River system. Three monthly progress reports have been submitted to the DFG during the sampling program. This report represents the final report submitted to the DFG, and incorporates a summary of all findings, conclusions, and recommendations for future sampling programs.

## Chapter 2

## STUDY AREA

The study area was located in the San Joaquin Valley and included approximately 280 miles of the San Joaquin River, Mendota Pool, and the Kings River system (Figure 1). Sampling was conducted on these rivers in San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings, and Tulare Counties. The majority of fish in the study area consist of introduced species: striped bass (Morone saxitilis), American shad (Alosa sapidissima), threadfin shad, largemouth bass (Micropterus salmoides), black crappie (Pomoxis nigromaculatus), white crappie (Pomoxis annularis), bluegill (Lepomis macrochirus), white catfish (Ictalurus catus), brown bullhead (Ictalurus nebulosus), and carp (Cyprinus carpio). The area occupied by these fish is classified as the Deep-bodied Fishes Zone (Moyle 1976). This zone occupies several major habitat types in the lower reaches of the San Joaquin and Kings Rivers including backwater sloughs, shallow tule beds, and long reaches of slow-moving water. Many of the native deep-bodied fishes which previously occupied this zone, such as Sacramento perch (Arcoplites interruptus), hitch (Lavinia exilicauda), and thicktail chub (Gila crassicauda), are either uncommon or extinct.

### San Joaquin River

The San Joaquin River Basin encompasses 11,000 square miles extending west from the Sierra Nevada crest to the Coast Range, and south from the San Joaquin Delta to the drainage dividing the San Joaquin and Kings Rivers. Principal tributaries of the San Joaquin River include the Stanislaus, Tuolumne, Merced, Chowchilla, and Fresno Rivers. All of these rivers are regulated by reservoirs.

#### Millerton Lake to Mendota Pool

This river segment has good water quality similar to other low elevation Sierra Nevada rivers. Reduced flows and increased water temperatures below Millerton Lake, however, have significantly altered aquatic habitat. Grassland and cultivated lands line the river with the exception of small tracts of willow (Salix spp.) and other riparian habitats.

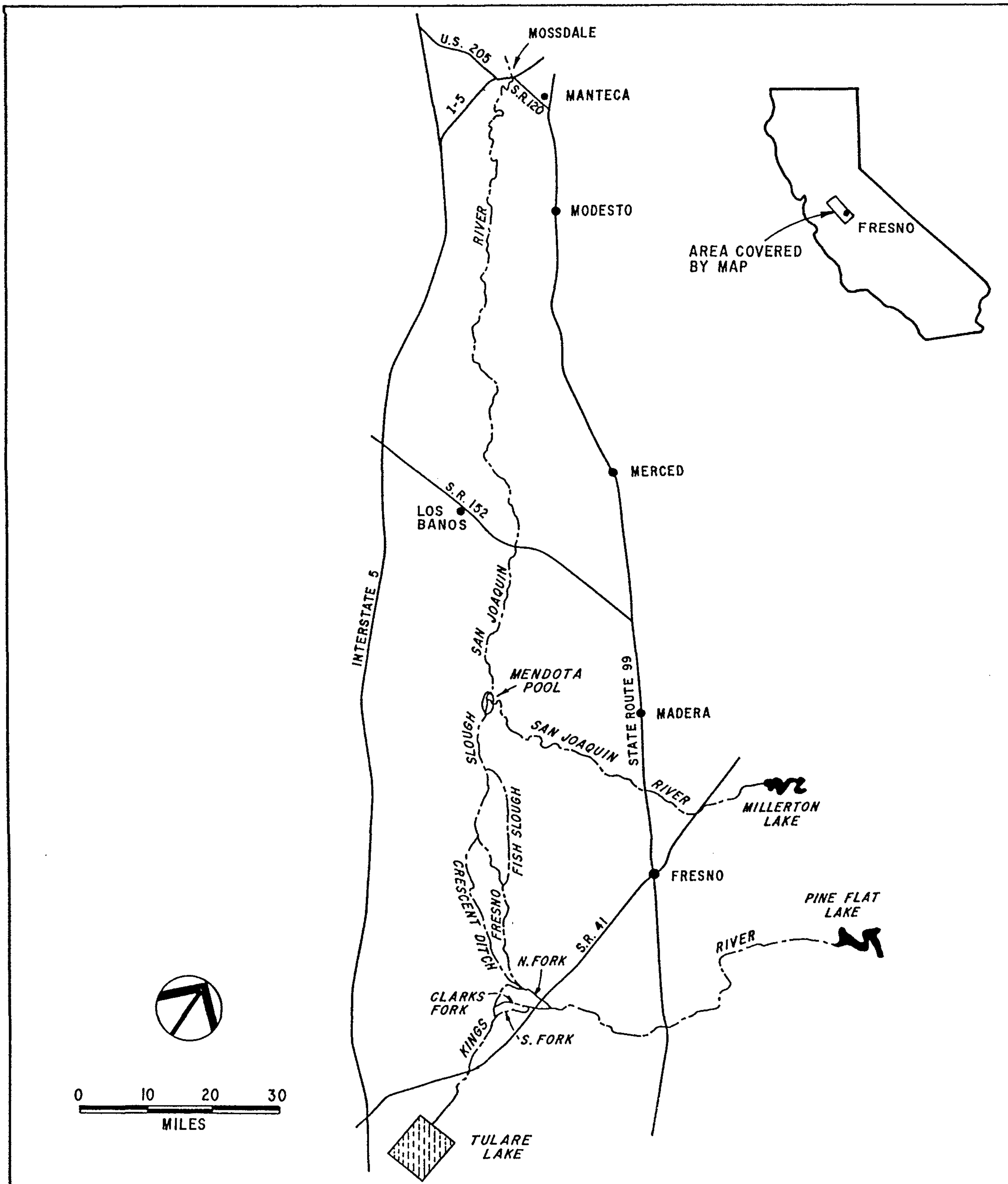


FIGURE 1. STUDY AREA LOCATION MAP

### Mendota Pool

Mendota Pool is located at the confluence of the San Joaquin River and Fresno Slough. The pool is a regulating reservoir used for receiving and transferring water diverted from the Sacramento-San Joaquin Delta via the Delta-Mendota Canal. Mendota Pool is approximately 1 mile long and varies from less than 100 to several hundred feet in width. Water depth varies, but is generally less than 15 feet. Steep banks are surrounded by shoreline covered with alkali bulrush (*Scirpus robustus*), cattail (*Typha* spp.), and saltgrass (*Distichlis spicata*).

### Mendota Pool to Merced River Confluence

Low flows and marginal water quality characterize this segment of the San Joaquin River. Several portions of the river are divided into small, high velocity channels by low grass-covered berms. Channel depths range from 2-8 feet. Aquatic habitat is diverse, consisting of backwaters and side channels. Riparian habitat consists primarily of willows interspersed with tall grasses.

### Merced River Confluence to Mossdale

High flows in this segment result from Merced, Tuolumne, and Stanislaus River inflows. The river is characterized by a wide, meandering channel containing sandbars, backwaters, and numerous subsidiary channels. The main channel is wide, ranging from 50 to 150 feet across; depth is variable, but generally ranges from 10-15 feet deep. Backwater and subsidiary channels are narrow and typically shallow in comparison to the main channel. Tall grasses and dense willow stands are interspersed with mud banks containing little vegetation.

## Kings River

The Kings River, with headwaters in the Sierra Nevada, is the major northernmost river of the Tulare Lake Basin; the Kaweah, Tule, and Kern Rivers are the other major rivers in the basin. Runoff from the Kings River reaches the Tulare Lake Basin during high water years. Flood flows in the Kings River enter the San Joaquin River via the Fresno Slough during exceptionally heavy runoff. These flood flows represent the only significant outflow from the basin.

### North, South, and Clarks Fork Kings River

These rivers are characterized by low flows, moderate temperatures, and marked fluctuations in water level; the latter is a function of water releases/diversions for irrigating farmland in the Tulare Basin. Several major weirs are located on these rivers, and water levels may fluctuate several feet daily during the irrigation season (typically late spring through fall). Small tracts of riparian habitat are interspersed with grassland/cultivated areas.

Crescent Bypass Ditch

Crescent Bypass is a dirt-lined canal with moderately steep banks connecting the Kings River with Fresno Slough. Channel width varies from 15-30 feet; depth is generally less than 4 feet. Little to no vegetation grows on channel banks. Instream fish habitat and water quality is very poor.

Fresno and Fish Sloughs

Fresno and Fish Sloughs are moderately wide (20-50 feet) channels with limited stands of riparian vegetation lining the levee banks. Water depth and volume varies both spatially and temporily depending on irrigation water requirements. Instream habitat is similar to that of some poorer reaches in the Kings River.

## Chapter 3

## METHODS

### Fish Sampling

Fish sampling was conducted from July 14 through October 11, 1986. Three 2-person teams sampled fish in the study area 4-5 days per week, approximately 8 hours per day. Team 1 sampled the San Joaquin River from the town of Mossdale upstream to Mendota Pool. Team 2 sampled fish in Mendota Pool and the San Joaquin River upstream to Millerton Lake. Team 3 sampled the Kings River system which included the Crescent Bypass Ditch; Fresno and Fish Sloughs; the North, South, and Clarks Fork Kings River; and the mainstem Kings River upstream to Pine Flat Reservoir.

Fish were sampled with several gear types to ensure randomness and reduce bias and selectivity inherent with the use of a single gear type (Powell et al. 1971; Yeh 1977; Hubert 1983). Gill nets, seines, fyke traps, boat electrofishing, and underwater observations were used to sample the various riverine habitats. Sampling gear and methodology used by each team during the study are described separately in the following sections.

#### Gill Nets

Each team sampled with both floating and sinking experimental gill nets. Each 125-foot net consisted of five 25-foot monofilament panels of variable-sized mesh, ranging from 1 to 4 inches stretched. At least two gill nets--a sinker and floater--were fished 4 days per week for a minimum of 4 hours per day or overnight. Night sets were made in areas of high water clarity if it was determined that fish were actively avoiding nets. Gill nets were fished according to habitat type. In high-velocity waters (e.g., lower San Joaquin River and upper Kings River), nets were set in backwaters, eddies, or anchored immediately downstream of tree snags. In slower current, gill nets were anchored at one end to streambank vegetation and by a cement weight to the stream bottom at the opposite end.

#### Seines

Beach seines were employed for use primarily in slow-moving, shallow water habitat along the river edge. Seines were 60 feet long by 6 feet deep with a 6-by-6-foot bag in the center. Mesh size was 3/16 inch. Seines were pulled twice daily, 4 days per week. In shallow, slow-moving water, seines were typically set in a circular pattern and closed by drawing the moving wall past the anchored end. In high-velocity areas, a motor boat was used to set and close the seine against the current.

## Fyke Traps

Each team deployed two 8-foot-long, 4-foot diameter fyke traps. Traps were designed, constructed, and initially placed by DFG personnel in Fresno. Traps were constructed of rebar hoops and 3-inch square wire mesh. Each fyke trap was set with the mouth facing downstream at depths which entirely covered the trap. Ropes were attached at either end of each trap and anchored by a fence stake to the streambank. Traps were fished continuously 4 days per week and checked daily. Fyke traps were moved several times during the study as sampling progressed upstream.

## Boat Electrofishing

Each team sampled fish 1 night per week for 4 weeks with a Smith-Root 12-foot aluminum electrofishing boat supplied by DFG. Teams 1, 2, and 3 electrofished in July, August, and September, respectively. Sampling was conducted at a rate of approximately 5 hours each night for a total of 20 hours sampling per team. Sampling sites were selected in a wide geographic range within each study area because of the limited availability of the boat electrofisher. Sampled habitat was restricted to slow, shallow-to-moderate depth rivers and backwater areas. The electrofishing crew consisted of two netters and a driver (a DFG fisheries biologist). Standard electrofishing techniques were used (Reynolds 1983).

## Underwater Observations

Underwater observations were employed only in areas of low water velocity and where water clarity equalled depth. Teams were divided into observer and recorder; the observer, equipped with mask and snorkel, floated on the water surface and identified and enumerated only those fish which could be positively identified to species. Observations were relayed every few minutes to the recorder on shore.

# Data Recording

Captured fish were counted and identified to species. Twenty-five randomly selected fish or the maximum number of each species captured, whichever was less, were measured (fork length in mm). Weights were obtained from fish greater than 80 mm fork length using portable spring scales. Sampling gear and habitat type were recorded. Fish captured in gill nets were categorized by panel (mesh size) and direction of travel (up- or downstream) when captured.

## Water Quality Sampling

Limited water quality data on dissolved oxygen, water temperature, pH, and water clarity (visibility) were recorded by each study team. Dissolved oxygen and pH were determined using field test kits. Water temperatures were recorded with hand-held thermometers. Water clarity was determined using secchi disks.

# Chapter 4

## RESULTS

### Fish Sampling

A total of 21,062 fish representing 33 species was collected during the 3-month study period. Over 300 man-days were used to sample approximately 280 river miles. White bass were not sampled or observed in the study area. Data sheets from the study are presented in three appendices bound separately (Appendices A, B, and C).

Table 1 provides a complete list of fish species sampled in the study area. Twenty-four species were introduced species; only nine species were native to the study area. Tables 2, 3, and 4 list the number of fish captured in subareas of the San Joaquin River; Kings River; and Crescent Bypass Ditch, Fish Slough, and Fresno Slough, respectively. The majority of species (30) occurred in the lower San Joaquin River (downstream of Mendota Pool) and Mendota Pool, and accounted for approximately 78 percent of the total catch. Twenty-four species were collected in the Kings River system. With the exception of threadfin shad, however, the abundance of individual species was low. Although variation existed between team study areas, the most abundant game species were bluegill, black and white crappie, largemouth bass, and white catfish. The most abundant nongame species were threadfin shad, mosquito fish, and Mississippi silverside. Rainbow trout were collected only in the Kings River downstream of Pine Flat Dam; this river segment receives cold-water releases from Pine Flat Reservoir.

Several hundred sunfish were collected during the study which could not be positively identified to species. Presumably, these fish are hybrids, lacking morphological characteristics necessary for identification. Such fish were classified as unidentified sunfish.

### Water Quality

Water quality was found to be acceptable for warmwater fishes in all sampled areas. Dissolved oxygen and water temperature, in particular, were within acceptable limits for warmwater fishes.

Table 1. Fish Species Sampled in the Study Area

| Family | Scientific Name | Common Name | Occurrence in Central Valley[a] |
|---|---|---|---|
| Petromyzontidae - lampreys | Lampetra tridentata | Pacific lamprey | N,A |
| Clupeidae - herrings | Alosa sapidissima | American shad | I,A |
| | Dorosoma petenense | Threadfin shad | I |
| Salmonidae - trouts | Salmo gairdneri | Rainbow trout | N |
| Cyprinidae - minnows | Cyprinus carpio | Common carp | I |
| | Carassius auratus | Goldfish | I |
| | Notemigonus crysoleucas | Golden shiner | I |
| | Orthodon microlepidotus | Sacramento blackfish | N |
| | Lavinia exilicauda | Hitch | N |
| | Ptychocheilus grandis | Sacramento squawfish | N |
| | Hesperoleucus symmetricus | California roach | N |
| Catastomidae - suckers | Catastomus occidentalis | Sacramento sucker | N |
| Ictaluridae - bullhead and catfish | Ictalurus punctatus | Channel catfish | I |
| | Ictalurus catus | White catfish | I |
| | Ictalurus nebulosus | Brown bullhead | I |
| | Ictalurus melas | Black bullhead | I |
| Poeciliidae - livebearers | Gambusia affinis | Mosquito fish | I |
| Atherinidae - silversides | Menidia audens | Mississippi silverside | I |
| | Menidia beryllina | Inland silverside | I |
| Percichthyidae - temperate basses | Morone saxitilis | Striped bass | I,A |
| Centrarchidae - sunfishes | Pomoxis nigromaculatus | Black crappie | I |
| | Pomoxis annularis | White crappie | I |
| | Lepomis gulosus | Warmouth | I |
| | Lepomis cyanellus | Green sunfish | I |
| | Lepomis gibbosus | Pumpkinseed | I |
| | Lepomis macrochirus | Bluegill | I |
| | Lepomis microlophus | Redear sunfish | I |
| | Micropterus salmoides | Largemouth bass | I |
| | Micropterus dolomieui | Smallmouth bass | I |
| | Micropterus punctulatus | Spotted bass | I |
| Percidae - perches | Percina macrolepida | Bigscale logperch | I |
| Embiotocidae - surfperches | Hysterocarpus traskii | Tule perch | N |
| Cottidae - sculpins | Cottus gulosus | Riffle sculpin | N |

[a] N = native
I = introduced
A = anadromous

Table 2. Captured Fish by Species in the San Joaquin River

| | Sampled Water | | | |
|---|---|---|---|---|
| | Mossdale to Mendota Pool | Mendota Pool | Mendota Pool to Millerton Lake | Total |
| Lamprey | 0 | 0 | 3 | 3 |
| American shad | 3 | 8 | 3 | 14 |
| Threadfin shad | 4,383 | 5,197 | 69 | 9,649 |
| Rainbow trout | 0 | 0 | 0 | 0 |
| Carp | 175 | 21 | 13 | 209 |
| Goldfish | 50 | 27 | 3 | 80 |
| Golden shiner | 8 | 4 | 52 | 64 |
| Sacramento blackfish | 63 | 0 | 1 | 64 |
| Hardhead | 16 | 0 | 2 | 18 |
| Hitch | 165 | 1 | 0 | 166 |
| Sacramento squawfish | 87 | 0 | 1 | 88 |
| California roach | 28 | 0 | 0 | 28 |
| Sacramento sucker | 3 | 3 | 77 | 83 |
| Channel catfish | 59 | 77 | 39 | 175 |
| White catfish | 177 | 9 | 52 | 238 |
| Brown bullhead | 1 | 4 | 3 | 8 |
| Black bullhead | 19 | 11 | 7 | 37 |
| Mosquito fish | 2,053 | 3 | 0 | 2,056 |
| Mississippi silverside | 1,613 | 0 | 2 | 1,615 |
| Inland silverside | 0 | 93 | 0 | 93 |
| Striped bass | 108 | 87 | 12 | 207 |
| Black crappie | 50 | 94 | 8 | 152 |
| White crappie | 91 | 47 | 7 | 145 |
| Warmouth | 4 | 6 | 10 | 20 |
| Green sunfish | 6 | 18 | 7 | 31 |
| Bluegill | 776 | 56 | 280 | 1,112 |
| Pumpkinseed | 7 | 8 | 2 | 17 |
| Redear sunfish | 140 | 0 | 75 | 215 |
| Largemouth bass | 149 | 10 | 316 | 475 |
| Smallmouth bass | 7 | 0 | 19 | 26 |
| Spotted bass | 7 | 0 | 10 | 17 |
| Bigscale logperch | 148 | 2 | 6 | 156 |
| Tule perch | 0 | 0 | 1 | 1 |
| Unidentified sunfish | 316 | 12 | 11 | 339 |
| TOTAL | 10,712 | 5,798 | 1,091 | 17,601 |

Table 3. Captured Fish by Species in the Kings River

| | Sampled Water | | | | |
|---|---|---|---|---|---|
| | Mainstem | North Fork | South Fork | Clark's Fork | Total |
| Lamprey | 0 | 0 | 0 | 0 | 0 |
| American shad | 0 | 0 | 0 | 0 | 0 |
| Threadfin shad | 10 | 0 | 105 | 0 | 115 |
| Rainbow trout | 27 | 0 | 0 | 0 | 27 |
| Carp | 143 | 9 | 11 | 0 | 163 |
| Goldfish | 23 | 0 | 0 | 0 | 23 |
| Golden shiner | 0 | 0 | 0 | 0 | 0 |
| Sacramento blackfish | 8 | 0 | 0 | 0 | 8 |
| Hardhead | 1 | 1 | 0 | 0 | 2 |
| Hitch | 5 | 0 | 0 | 0 | 5 |
| Sacramento squawfish | 2 | 1 | 0 | 0 | 3 |
| California roach | 5 | 0 | 0 | 0 | 5 |
| Sacramento sucker | 36 | 0 | 0 | 0 | 36 |
| Channel catfish | 10 | 2 | 7 | 0 | 19 |
| White catfish | 0 | 0 | 2 | 0 | 2 |
| Brown bullhead | 1 | 0 | 0 | 0 | 1 |
| Black bullhead | 3 | 0 | 1 | 0 | 4 |
| Mosquito fish | 0 | 0 | 0 | 0 | 0 |
| Mississippi silverside | 0 | 0 | 0 | 0 | 0 |
| Inland silverside | 0 | 0 | 0 | 0 | 0 |
| Striped bass | 0 | 3 | 0 | 0 | 3 |
| Black crappie | 16 | 4 | 1 | 1 | 22 |
| White crappie | 32 | 0 | 2 | 2 | 36 |
| Warmouth | 0 | 0 | 0 | 0 | 0 |
| Green sunfish | 4 | 0 | 0 | 0 | 4 |
| Bluegill | 249 | 6 | 4 | 2 | 261 |
| Pumpkinseed | 0 | 0 | 0 | 0 | 0 |
| Redear sunfish | 0 | 0 | 0 | 0 | 0 |
| Largemouth bass | 47 | 0 | 8 | 0 | 55 |
| Smallmouth bass | 69 | 1 | 0 | 0 | 70 |
| Spotted bass | 1 | 0 | 0 | 0 | 1 |
| Bigscale logperch | 2 | 0 | 0 | 0 | 2 |
| Tule perch | 0 | 0 | 0 | 0 | 0 |
| Sculpin | 30 | 0 | 0 | 0 | 30 |
| Unidentified sunfish | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 724 | 27 | 141 | 5 | 897 |

Table 4. Captured Fish by Species in the Crescent Bypass Ditch and Fresno and Fish Sloughs

| Species | Sampled Water: Crescent Bypass Ditch | Sampled Water: Fresno and Fish Sloughs | Total |
|---|---|---|---|
| Lamprey | 0 | 0 | 0 |
| American shad | 0 | 0 | 0 |
| Threadfin shad | 0 | 2,237 | 2,237 |
| Rainbow trout | 0 | 0 | 0 |
| Carp | 0 | 24 | 24 |
| Goldfish | 1 | 8 | 9 |
| Golden shiner | 0 | 0 | 0 |
| Sacramento blackfish | 0 | 0 | 0 |
| Hardhead | 0 | 0 | 0 |
| Hitch | 0 | 27 | 27 |
| Sacramento squawfish | 0 | 0 | 0 |
| California roach | 0 | 0 | 0 |
| Sacramento sucker | 1 | 6 | 7 |
| Channel catfish | 0 | 33 | 33 |
| White catfish | 0 | 4 | 4 |
| Brown bullhead | 0 | 2 | 2 |
| Black bullhead | 1 | 8 | 9 |
| Mosquito fish | 0 | 26 | 26 |
| Mississippi silverside | 0 | 0 | 0 |
| Inland silverside | 0 | 17 | 17 |
| Striped bass | 0 | 2 | 2 |
| Black crappie | 5 | 23 | 28 |
| White crappie | 0 | 23 | 23 |
| Warmouth | 0 | 0 | 0 |
| Green sunfish | 0 | 6 | 6 |
| Bluegill | 0 | 66 | 66 |
| Pumpkinseed | 0 | 0 | 0 |
| Redear sunfish | 0 | 0 | 0 |
| Largemouth bass | 2 | 32 | 34 |
| Smallmouth bass | 0 | 2 | 2 |
| Spotted bass | 0 | 0 | 0 |
| Bigscale logperch | 0 | 0 | 0 |
| Tule perch | 0 | 0 | 0 |
| Unidentified sunfish | 0 | 8 | 8 |
| TOTAL | 10 | 2,554 | 2,564 |

# Chapter 5

## DISCUSSION

The lower San Joaquin River and Mendota Pool were the most important sampling areas in terms of both fish species diversity and abundance. The lower San Joaquin River also has the greatest habitat diversity with many backwaters and side channels. In general, the greatest catch of most species occurred in backwater areas. Native cyprinids and introduced centrarchids, including largemouth bass, white and black crappie, and sunfish, were most abundant in this habitat. A single fish tentatively identified as a tule perch was collected and released in the San Joaquin River. This identification is considered uncertain, however, because tule perch were not thought to be present in the San Joaquin River (Moyle 1976).

Habitat preference for backwater areas was also observed while electrofishing in the Clarks Fork Kings River; few species occurred in the main channel. When several side channels were sampled, species diversity and total numbers increased greatly. In general, the catch in the Kings River system was low. This may be partially attributable to poor sampling conditions; high flows (>2,500 cfs) in the mainstem precluded effective sampling with seines and gill nets. The problem was exacerbated by the lack of suitable sampling habitat such as backwater and quiet water areas. Study results suggest that the most effective sampling technique in the mainstem was boat electrofishing. Another possible factor related to the low catch rate in the Kings River system was fluctuating water levels caused by several major diversion dams (weirs). For example, daily water level fluctuations of several feet were observed in Fresno Slough.

Over 12,000 fish (57 percent) of the total number sampled were threadfin shad. More than 9,000 threadfin shad occurred in the slow, open-surface waters of Mendota Pool and the backwaters of the lower San Joaquin River. Threadfin shad are the primary forage fish of adult white bass (Chadwick et al. 1966; Olmsted and Kilambi 1971; Hamilton and Nelson 1984). Several researchers cited by Hamilton and Nelson (1984) have reported that shad accounted for the greatest percentage of fish biomass where white bass were captured. It is likely that white bass, if present, would have been captured in the study area because of the strong predator-prey relationship between white bass and threadfin shad (Jenkins and Elkin 1957). Nonetheless, the possibility exists that white bass are present in the study





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area and avoided capture, especially given the large geographical area under study. We believe the probability of occurrence of white bass is extremely low in view of the extensive and intensive sampling effort used in the study.

Chapter 6

# RECOMMENDATIONS

## Additional Sampling and Study Area Modification

At least one additional year of sampling within the study area is recommended because of the large area sampled and importance of monitoring the status of white bass. Efforts should be concentrated, however, in areas where overall catch rates were greatest (e.g., Mendota Pool; specific reaches of the San Joaquin River). Furthermore, effort should be directed toward sampling habitats occupied by threadfin shad; white bass have been found to be more sensitive to prey location than to habitat features (Hamilton and Nelson 1984). The open surface waters of Mendota Pool provide excellent threadfin shad habitat, and future sampling efforts should be concentrated in this area.

Sampling effort should be concentrated in the Kings River system closer to the source of known white bass occurrence--the Tulare Take area and Pine Flat Reservoir. Locating suitable sampling sites in these areas, and then expending more effort sampling in slow, quiet waters of main channels and backwaters may be more effective than moving sampling sites on a daily basis. A great deal of time and effort was expended in locating access sites that sometimes maintained poor fisheries habitat.

## Larval Fish Sampling

A larval fish sampling program in June and July should be considered. White bass spawn in spring when water temperatures exceed 12-14°C (Webb and Moss 1968; Ruelle 1971), and hatching occurs within several days of spawning. White bass larva concentrate in backwater habitats which could be sampled effectively. A major benefit of larval sampling would be the potential for initiating an action to control white bass prior to the further dispersal of larval fish and their subsequent maturity and spawning. A major drawback is the time and expense involved in collecting, preparing, and identifying larval fish. Thousands of larval fish would be captured and each fish would require positive identification.

## Gear Modification

Sampling gear used in this study was very effective. Several changes are recommended for future sampling, however, which could increase catch without increasing effort:

- Eliminate snorkeling; this sampling method was feasible only in limited reaches of the upper San Joaquin River, and resulted in only a few direct observations.

- Increase number of seine hauls; 4 or 5 seine hauls per day over several hours could result in a greater catch. Sampling time would increase only slightly.

- Locate fyke traps in areas of greatest fish concentration as determined in this study, and install locking devices to prevent trap vandalism. Trap location on private lands should be considered to reduce trespassing and vandalism. Baited traps may increase overall catch.

- Increase electrofishing effort, particularly in the Kings River system. Electrofishing is a highly effective sampling method and works well in shallow, medium-velocity rivers such as the forks of the Kings River. We recommend increasing electrofishing to 2 nights per week while sampling the Kings River system. Gill netting and seining, which were not very effective in this area, could be reduced slightly to compensate for the additional time allocated to electrofishing.

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